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Multiplicity in the Small Magellanic Cloud

The study of protoplanetary disks involves the analysis of many physical properties of the dusty disks that surround young stars. To gain a complete understanding of planet formation, it is vital to look at planet formation from the early Universe to present day. Given that astronomers do not yet have access to a time machine, we need to find another way to peer back in time and gain understanding of how the earliest planets formed.

Early planets formed in a low abundance of heavy elements like carbon, oxygen, and silicon. Each element on the periodic table was built in the cores of stars through iterations of stellar evolution. Within the lifetime of a star it undergoes nuclear fusion in its core, and systematically builds atomic elements. Upon a star's death, those elements are spewed into the cosmos when a star explodes and are then used as ingredients for future processing of other stars and their planetary systems. Looking for planets in galaxies with lower abundances of the heavier elements (referred to as "metal-poor") are an astronomer's best tool for gaining understanding of early planet formation. We have found a sample of stars in the Small Magellanic Cloud (SMC) that appear to be intermediate mass stars with young solar systems forming around them, Herbig Ae/Be (HAEBE) stars. The SMC is a dwarf galaxy located ~ 200,000 light years from the Milky Way and has 1/5 the heavy element abundance that the sun does. In studying HAEBE stars in the SMC, using archival images from the Hubble Space Telescope (HST), I have discovered that one of the "stars" is actually a group of more than 10 individual objects. This complicates the analysis of the star as a young solar system.

I joined an ongoing search for young stellar objects in the SMC (Keller et al., 2019) where my task was to help write proposals to gain observing time with telescopes that have better spatial resolution (image detail). A survey of candidate protoplanetary disk objects already existed but needed images and spectra with enhanced detail as well as observations in the UV portion of the electromagnetic spectrum. During the proposal writing process I found optical wavelength HST images in four different colors that shows one candidate as more than 10 individual objects when imaged in higher resolution.

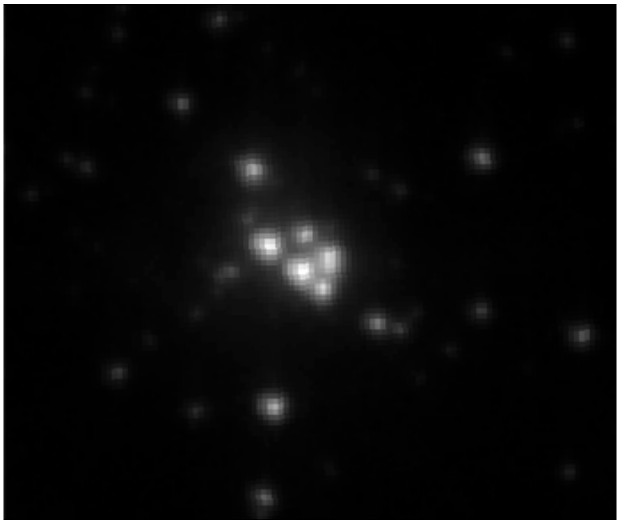
Figure 1. Multiplicity object showing >10 point sources.

Using these 4 images from the HST archive, I used a program called ATV to measure the intensity of light coming from each object, also called photometry. I then plotted the intensities from each image vs. the wavelength they were measured in and compared them to known stellar models. These plots are called spectral energy distributions (SEDs) and are used to characterize the objects temperature as well as many other physical features of the object.

Spectral energy distributions of the nine brightest objects in the multiplicity source show individual temperatures ranging from 5,700 to 27,000 Kelvin before correcting for the scattering of light from dust between the telescope and the object, and temperatures ranging from 11,000 to >50,000 Kelvin after dust corrections. Correcting for dust scattering along our line of sight to objects as far away as the SMC can be a difficult process and the analysis for these objects is still being considered.

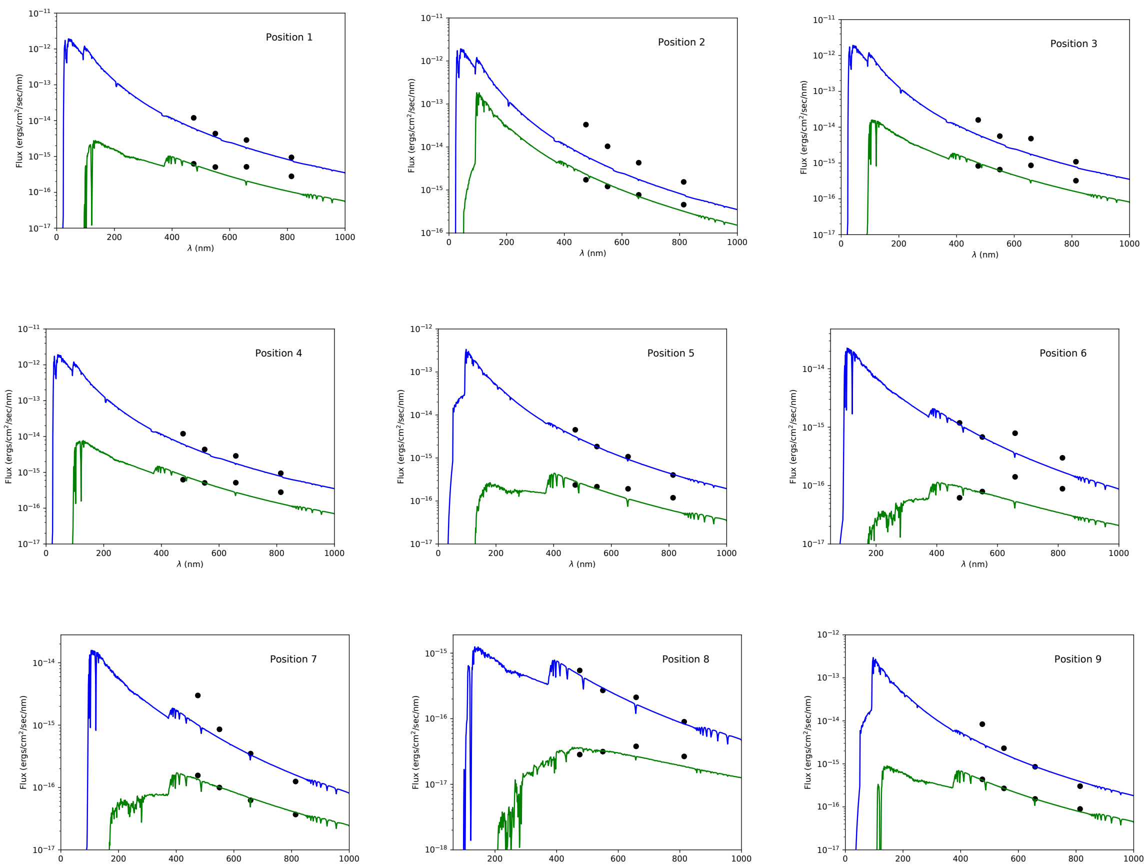

Figure 2. Spectral Energy Distributions for the nine brightest objects of SMC multiplicity source.

Given preliminary data, I have identified a point source in the SMC that has excess IR emission that resembles Herbig Ae/Be stars. Further investigation with higher resolution HST archival images shows that this source as multiple objects (more than 10), one of which shows excess in the I band (814 nm) and may be the only source of IR emission. To better confine our data for this source and for the rest of the Herbig Ae/Be sample, near- and mid-infrared spectroscopy at higher resolution is needed, like that of HST and JWST (0.07-0.15 FWHM, 70 milli-arcsec FWHM, respectively). This research gives tangible evidence of the uncertainty that comes from imaging objects outside of the Milky Way and offers as a warning to other astronomers who do research in the Large and Small Magellanic Clouds.